STATEMENT OF WORK

The Contractor shall provide Navy-oriented engineering support to the Carderock Division, Naval Surface Warfare Center (NSWCCD), Hydromechanics Directorate. The scientific and technical subject matter of the support encompasses powering, hydromechanics, aeromechanics, and dynamics for conventional ships, submarines (the term to be inclusive of other underwater vehicles), aircraft, air platforms, and advanced craft. Disciplines within these subject areas include ship/system design and development, control system design and validation, computer system development, conversion support, computer modeling and simulation, artificial intelligence, neural networks development, numerical analysis and tool development, propulsion and resistance evaluation, stability and control, ship motions, seakeeping, ocean environment modeling, data analysis, mathematical modeling, simulation; man-machine interface design, control system and trainer real-time software development, software configuration management, programmatic support, logistics, Computational Fluid Dynamics (CFD), physics based modeling, special projects, planning and quality control, database development and support. The Contractor shall also provide engineering and program management support for the planning, design, fabrication and acquisition of new facilities and sea based platforms, and the conduct of tests in various hydromechanics, hydro-acoustics and off shore facilities. Further, the contractor shall provide design, fabrication of models, full-scale systems and test apparatus as necessary to demonstrate technological feasibility or prove design concepts. The support to be provided shall be subject to the issuance of delivery orders, which shall define the work to be performed, in accordance with the statement of work set forth below:

Task Area 1 Ship Maneuvering, Stability and Control

a. Develop and conduct test plans by determining the objective of the set of tests, determining the measurements which must be made to accomplish test objectives, specifying and fabricating the instrumentation needed to obtain the required measurements, preparing instrumentation plans and briefs, establishing the support requirements for the test, and developing the format in which data is to be recorded.

b. Reduce and analyze model test data obtained from planar motion mechanism experiments and rotating arm experiments to obtain stability derivatives and coefficients of the equations of motion for submarines and surface ships.

c. Prepare plans and analyses to support the conduct of Radio Controlled Model (RCM) experiments. Reduce and analyze RCM test data. Utilize RCM test data and other data to develop CFD and physics based models.

d. Reduce and analyze full-scale trails data and correlating model, RCM, and full-scale data. Develop and modify computer programs to aid in data reduction and analysis efforts.

e. Predict the dynamic response to environmentally produced forces and moments in a time and/or frequency domain utilizing the Newtonian laws of motion.

f. Develop analytical subsystem models, which employ classical methods to represent physical phenomena. Develop database subsystem models, which employ "table look-up" or "function fitting" methods designed to utilize data obtained through scale model experimentation. Code the simulation design in accordance with standard industry practices such as IEEE, etc. The software shall be structured and controlled so that an easily comprehended simulation code can be maintained throughout the lifetime of the simulation.

g. Develop the necessary software to present computerized graphical comparison plots of experimental and simulated results in both the time and frequency domains. Perform statistical tests to verify the model as an accurate representation of the submarine operation.

h. Develop and modify simulation models to improve predictions of dynamic response to sea state environment produced forces and moments.

i. Design and fabricate the test and instrumentation circuitry to support the conduct of model and full-scale trials and acquisition of data. Develop the installation and checkout procedures for the instrumentation package. Install and test the full-scale trials instrumentation package. Remove of the instrumentation following trials completion, and restore the vessel/test facility to its pretrial condition.

j. Provide reports documenting the results of the above analyses, conforming to the format, procedures, and standards of NSWCCD reports and including the necessary curves, graphs, and tables of data, which also follow NSWCCD format.

Task Area 2 Ship Powering and Resistance

a. Develop and conduct test plans by determining the objective of the set of tests, determining the measurements which must be made to accomplish test objectives, specifying and fabricating the instrumentation needed to obtain the required measurements, preparing instrumentation plans and briefs, establishing the support requirements for the test, and developing the format in which data is to be recorded.

b. Analyze resistance test data, perform effective power predictions and prepare effective power curves. Identify displacement and wetted surface calculations and Taylor Standard Series comparisons.

c. Analyze self-propulsion test data and propeller test data. Determine shaft horsepower, calculate propulsion coefficients and prepare shaft horsepower prediction curves.

d. Perform calculations of correlations between existing model data and full-scale data. Analyze experimental data for surface wake characteristics.

e. Develop databases of ship characteristics to be used in making resistance predictions. Develop computational tools for resistance predictions.

f. Provide reports documenting the results of the above analyses, conforming to the format, procedures, and standards of NSWCCD reports and including the necessary curves, graphs, and tables of data, which also follow NSWCCD format.

Task Area 3 Ship Propulsion and Propulsors

a. Develop and conduct test plans by determining the objective of the set of tests, determining the measurements which must be made to accomplish test objectives, specifying and fabricating the instrumentation needed to obtain the required measurements, preparing instrumentation plans and briefs, establishing the support requirements for the test, and developing the format in which data is to be recorded.

b. Reduce and analyze model and full-scale trials data and design predictions in order to validate and correlate propulsor performance. Develop computer programs needed to facilitate rapid data analysis.

c. Carry out calculations using propeller lifting surface and other propeller theories and comparing with experimental measurements or other predictions of performance. These tasks may require representation of data using harmonic analysis and the development of tables and figures in support of the analytical efforts.

d. Perform propulsor experiments and/or evaluate propulsor data for tests in the NSWCCD towing tanks, 36 and 24 inch water tunnels, Large Cavitation Channel, and other test facilities.

e. Develop and exercise computer programs to predict propulsor performance. Develop graphics software to represent propulsors and their performance.

f. Provide reports documenting the results of the above analyses, conforming to the format, procedures, and standards of NSWCCD reports and including the necessary curves, graphs, and tables of data, which also follow NSWCCD format.

Task Area 4 Ship Motions, Stability, and Seakeeping

a. Develop and conduct test plans by determining the objective of the set of tests, determining the measurements which must be made to accomplish test objectives, specifying and fabricating the instrumentation needed to obtain the required measurements, preparing instrumentation plans and briefs, establishing the support requirements for the test, and developing the format in which data is to be recorded.

b. Conduct stability and control experiments, reducing and analyzing model test and full-scale trials data to obtain response amplitude operators for all six degrees of freedom. Reduce and analyze test data to obtain ship responses in terms of motions, statistical events, and probability distributions.

c. Develop tables and figures in support of the analytical efforts prepared in accordance with established format identified in task statements.

d. Develop/modify/document the analytical tools utilized in seakeeping performance assessment. Identify and collect the source information necessary to implement the analytic tools.

e. Implement the analytic tools and developing a graphical database for all performance limits. Perform an analysis of graphical database and summarizing the seakeeping performance of the ships being assessed.

f. Develop databases of ship responses for a variety of wave spectra models. Evaluate results for each model's ability to predict ship responses. Perform comparisons for different ship types, and provide camera-ready graphics of these comparisons.

g. Analyze existing and new offshore platforms including moored platforms, towed platforms and surface ships for structural integrity, static and dynamic stability, and sea keeping.

h. Provide reports documenting the results of the above analyses, conforming to the format, procedures, and standards of NSWCCD reports and including the necessary curves, graphs, and tables of data, format of which will be specified in task statements.

Task Area 5 Digital Automatic Control Systems

a. Develop the initial mathematical model of the vehicle, to describe its responses to external hydrodynamic and dynamic forces and disturbances. Develop parameters of this model from known hydrodynamic and fluid dynamic theory and/or system identification techniques.

b. Implement the model structure and its parametric values via computer software for the purposes of simulation and validation. Perform statistical tests to verify the model as an accurate representation of the physical system. Examine the sensitivity of performance to perturbations in model parameters using the simulation.

c. Establish the feasibility of control strategies and the required control system specifications with respect to the functions of the controller. Define acceptable control structures by considering the critical concepts of controllability and stability of the vehicle. Establish the necessary system specifications in terms of the desired system performance and operational constraints.

d. Design, fabricate and simulate a control system using either (or both) the classical or modern (optimal) method. Document the selection of the technique to be used.

e. Provide human operator modeling and human factors engineered man-machine interface design for control systems.

f. Perform sensitivity studies for the control system using computer simulations.

g. Evaluate and compare various control system designs with respect to desired performance qualities.

h. Develop and improve existing math models. Develop the simulation software required to verify and validate these modifications, and performing sensitivity studies to determine the effect of these modifications.

i. Provide reports documenting the results of the above analyses, conforming to the format, procedures, and standards of NSWCCD reports including the necessary curves, graphs, and tables of data, which also follow format identified in task statements.

Task Area 6 Estimation Algorithms and Operator Aided Information Systems

a. Develop the initial mathematical model of the vehicle, to describe its responses to external hydrodynamic and dynamic forces and disturbances. Develop parameters of this model from known hydrodynamic and fluid dynamic theory and/or system identification techniques.

b. Implement the model structure and its parametric values via computer software for the purposes of simulation and validation. Perform statistical tests to verify the model as an accurate representation of the physical system. Examine the sensitivity of performance to perturbations in model parameters using the simulation.

c. Establish the feasibility of estimation strategies and the required estimation system specifications with respect to the functions of the system. Define acceptable estimation structures by considering the critical concepts of data fusion and man-machine interface. Establish the necessary system specifications in terms of the desired system performance and operational constraints.

d. Design, fabricate and simulate an estimation system using any of a number of techniques including artificial intelligence, neural networks, fuzzy logic, heuristic reasoning, rule-based methods, and other intelligent concepts. Document the selection of the technique to be used.

e. Perform sensitivity studies for the estimation system using computer simulations.

f. Evaluate and compare various estimation system designs with respect to desired performance qualities.

g. Provide reports documenting the results of the above analyses in the format identified in the individual statements of work and within industry standard practices.

Task Area 7 Hydrodynamic, Hydroacoustic, Aeromechanic and Aerodynamic Test and Evaluation Programs, for Both Model-Scale and Full-Scale Vehicles

(Note that these may be conducted in laboratories and test facilities located at NSWCCD, remote sites, and also on full-scale trials of ships, submarines, and air platforms as required.)

a. Develop and conduct test plans by determining the objective of the set of test, determining the measurements which must be made to accomplish trial objectives, specifying and fabricating the instrumentation needed to obtain the required measurements, preparing instrumentation plans and briefs, establishing the support requirements for the test, and developing the format in which data is to be recorded.

b. Provide engineering assistance to solve problems encountered in the planning, setup, and conduct of test and evaluation of programs.

c. Design, fabricate, modify, and evaluate mechanical and electronic instruments for; taking measurements, mounting hardware, acquiring, recording, and analyzing data from test and evaluation programs. Develop designs from engineering concepts and provide detailed engineering drawings for mechanical, electro-mechanical, hydraulic, pneumatic and electronic systems to be used for conducting test and evaluation programs.

d. Design, fabricate, and modify all hardware (including model-scale hulls, propulsors and full-scale components) for conducting test and evaluation programs. Perform various full-scale propeller modifications as required to verify performance predictions.

e. Assist in the inspection of components to ensure that the intended performance of facility, hardware, and test /valuation program is met. Perform inspection of hardware comparing the as built geometry to the designed geometry.

f. Assist in the development and evaluation of operation and maintenance procedures for test and evaluation programs, support systems and facilities.

g. Perform calculations to assist NSWCCD in the evaluation of the readiness of hardware, equipment, facilities, and related systems for test and evaluation programs.

h. Provide reports/engineering drawings documenting the results of the above, as specified in each delivery order. Reports shall include curves, graphs, and tables of data. Engineering drawings shall be done using CAD (Computer Aided Design) drawing programs as specified in the delivery order.

Task Area 8 Ship Control Systems Design, Life Cycle, and Software Safety Analysis Support

a. Provide analytical and technical support evaluating system level performance of ship control systems and all related elements, with the principal objective of developing methods for assuring hardware and software safety and accurate performance, adequate reliability and maintainability, and providing related technical engineering support to the Program Manager (PM) and In-Service Engineering Agent (ISEA) independent of the Principal Design Agent (PDA).

b. Investigate emergent hardware and software problems including causes and proposed solutions. Utilize data available from dockside testing, builder's trials, special trials, Post Shakedown Availability (PSA) trials, Inspection and Survey (INSRV) trials, patrol generated problems and failure reports. Problem areas include ship control station, position control units, sensors and tactical software.

c. Support the preparation and conduct of Shipbuilder fabrication, installation and testing of tactical ship control systems and other non-propulsion electronic (NPE) systems components, including review of test schedules and test plans for ships under construction. Review tactical ship control systems and other NPE system hardware fabricated by the Shipbuilder for compliance with ship specifications and drawings. Review test schedules to ensure the system integration testing will adequately support ship schedules and that test plans are adequate to meet the requirements specified in the ship and system specifications. Verify that all ship control systems and other NPE system tactical hardware and software functions are exercised by the integration tests with appropriate pass/fail criteria to verify system performance compliance with ship and system specification requirements.

d. Conduct in-depth analyses of work center logs, patrol logs, patrol tapes, problem reports, 2-kilos, refit work packages and post refit reports. Identify problems in system performance, component operation, and degradation trends in ship control system operation.

e. Review and monitor status of design changes and design problems outside of the ship control system and identifying any impacts on the ship control system. Participate in working groups assigned to follow such activities outside the ship control system.

f. Perform engineering analysis of shipyard installation procedures, construction schedules, ship control station Rapid Installation Programs (RIPs), integration and testing of new hulls. Perform ship control system software revision installation and validation testing. Review new construction Quality Deficiency Reports (QDRs), problem reports, compiling data, and performing trend analysis.

g. Analyze impact on ship control performance resulting from proposed changes in interfacing systems and quantifying effects on ship control.

h. Prepare Engineering Change Proposals (ECPs) required to modify the ship control system to implement required changes.

i. Technically review all ship control configuration change control documentation, Preliminary Engineering Change Proposals (PECPs), ECPs and problem reports. Verify the technical accuracy and need for the changes, as well as consistency, with the ship control Configuration Management (CM) plan. Documentation includes Ship Control Station Technical Manuals, Ship Systems Manuals, Maintenance Requirements Cards, Maintenance Plans, Standard Maintenance Procedures (SCSTMs, SSMs, MRCs, MPs, SMPs), and drawing plans and test procedures. Assist with the maintenance of the library of technical documents.

j. Perform software configuration management and maintain status for all tactical ship control system and trainer software and documentation.

k. Implement and test approved changes to the tactical ship control system and trainer software. Develop software and perform software quality assurance evaluation. Develop software change packages for the approved software changes, including documentation changes and certified software releases.

l. Provide engineering assistance during special trials, Demonstration and Shakedown Operations (DASOs), refit periods, Post Shakedown Availability (PSA), and Refueling and Engineering overhauls (ROH, EOH) to develop corrective actions and emergent temporary engineering changes. Support the planning, development, fabrication, installation, and testing of required engineering changes for shipyard or shore-based facility ship control system hardware and software.

m. Conduct software safety analyses of ship control system software, including automatic control and estimation algorithms and risk management analyses of software development processes. Provide independent review and assessments of ship control system safety analyses produced by the Shipbuilder/ Lead Design Yard.

n. Provide reports documenting the results of the above analyses in the format identified in task statements complying with industry standards.

Task Area 9 Hydrodynamic Facility Repair and Upgrade

a. Provide engineering and design support in hydrodynamic facility repair and upgrade projects. This shall include but not be limited to the design and analysis of; structures, hydraulic systems, and power transmission systems.

b. Fabricate and assemble mechanical parts and systems. Integrate new mechanical systems into existing hydrodynamic facilities and verify proper function and performance.

c. Document mechanical systems by preparing electronic drawing packages. Provide electronic data for in house manufacture when needed. Provide 3-D models of mechanical systems for future modification and repair when needed.

Task Area 10 Dynamic Control System Simulator (DCSS) Computer System and Submarine Motion Base Simulator Software and Hardware Conversion

a. Adapt submarine vehicle dynamics simulations for real-time use with the DCSS submarine motion base simulator.

b. Program graphics software for use on the Submarine Motion Base Simulator in conjunction with DCSS real-time simulations.

c. Develop user oriented documentation describing limitations and use of the Submarine Motion Base Simulator for real-time programming and graphics software.

d. Convert data files from one storage medium to a new storage medium to accommodate a change in computer system architecture. Convert or transfer software programs from one computer system to a new system including the removal of machine dependent software coding in the programs, converting the job control language, etc. Converting software from one higher order language to another; e.g. FORTRAN 77 to Ada, FORTRAN to C, and Ada to C and between FORTRAN 77 and 90.

e. Develop data acquisition software, real-time control software and data reduction software for use on the DCSS simulation computer and Submarine Motion Base Simulator.

f. Convert laboratory unique simulation software to transportable, supportable, tactical and training system standards.

g. Develop software analysis, requirements, design and test documentation.

h. Provide reports documenting the results of the above analyses in the format identified in the individual statements of work and within industry standard practices.

Task Area 11 Special Systems such as Unmanned Vehicles, Underwater Bodies, Offshore Platforms, and Marine and Special Systems

a. Analyze and evaluate data in the hydrodynamic performance of special systems such as weapons launching systems, masking systems, unmanned air vehicles (UAVs), unmanned undersea vehicles (UUVs), and towed, moored, or tethered systems.

b. Develop prediction methods for the definition of flows around underwater bodies.

c. Utilize prediction tools to obtain definition of flows around underwater bodies.

d. Develop and fabricate instrumentation and developing data acquisition plans to acquire experimental data on fluid flows.

e. With regard to UAVs and UUVs: Determine aerodynamic and hydrodynamic coefficients; develop and evaluate designs; develop simulation models; develop algorithms for stability, control and maneuvering; evaluate powering and resistance; conduct stability and control experiments; and analyze data.

f. Provide reports documenting the results of the above analyses, conforming to the format, procedures, and standards of NSWCCD reports and including the necessary curves, graphs, and tables of data, which also follow NSWCCD format. Specific format to be identified at the time of tasking.

g. Analyze moored systems, buoy system and towed systems to develop prototype designs including mechanical design, hydrodynamic design, and static and dynamic response of systems in ocean environments.

h. Analyze and develop auxiliary systems and components to support moored, buoy, towed and marine systems in areas such as cables, towlines, fairings, winches, antennas, instrument canisters, fairings, fiber optics, telemetry, data collection systems, drogues, and handling systems.

i. Develop moored system, buoy system, towed system and marine system prototype designs into operational systems including fabrication, testing, instrumentation and analysis of these systems and their auxiliary components in model-scale and full-scale.

j. Analyze and develop electronic and microprocessor based sensor packages and control systems to support moored, buoy, towed and marine systems programs.

k. Design and develop offshore platforms using analysis, model scale testing and full-scale testing.

l. Modify existing offshore platforms and constructing new offshore platforms in model-scale and full-scale.

m. Modify existing offshore platform systems and constructing new offshore platform systems in model-scale and in full-scale.

n. Support model-scale and full-scale trials, testing and operations on offshore platforms including planning, management, sensors, electronics, instrumentation, trade support, medical services, supplies and provisions procurements, maintenance, rentals and other required services.

Task Area 12 Logistics Support

a. Perform reliability, maintainability and availability assessments and predictions for NSWCCD equipment, facilities and systems. Conduct Failure Modes, Effects and Criticality Analysis (FMECA) to the lowest repairable level. Develop life cycle cost models and conducting life cycle cost analyses.

b. Develop Integrated Logistic Support Plans (ILSP), provisioning plans and instrumentation support plans to identify planning and support requirements. Identify data sources, interfaces

with other functional activities and requirement interdependencies. Conduct logistic support analyses (LSA) and level of repair analyses (LOR), and update provisioning data, documentation and parts lists.

c. Identify and develop preventive maintenance schedules, calibration requirements, corrective maintenance procedures, safety precautions to support system and equipment maintenance actions, and replacement or repair of obsolete equipment.

d. Evaluate the logistic effect of engineering change proposals including maintenance, supply support, special tools and test equipment, computer resources, technical documentation, facilities, and storage/transportation.

e. Provide reports documenting the results of the above analyses in the format identified in the individual statements of work and within industry standard practices.

f. Provide design solutions for replacement or repair of obsolete systems, or facilities used for aerodynamic, aeromechanical, hydrodynamic and or hydro acoustic evaluations. Procure and or manufacture the necessary hardware, install and test to make sure the repaired and /or replacement hardware meets necessary specifications.

Task Area 13 Fabrication of Plane, Ship and Submarine Hardware

a. Maintain fabrication facilities, including but not limited to: Computer Numerically Controlled (CNC) machines, manual machine tools, hand tools, inspection capabilities, lifting facilities, and the size of layout tables for models. The contractor shall maintain capability to fabricate ship and submarine hardware up to 40 ft. in length and their appendages, using composite materials (i.e., fiberglass), wood and aluminum materials. The contractor shall have the capabilty either in house or through a subcontractor to build hardware with the following tolerances:

- (±) 1/8 inch on length
- (±) 1/16- inch relative to section template
- (±) 1/32- inch fairness requirement over 6-inches
- (±) 63 micro-meters RMS (Root Mean Square) smooth fair finish

b. Fabricate Propulsors and Open Propellers Using CNC Machines. Fabricate propulsors (stators, ducts, and rotors) in addition to open propellers using Computer Numerically Controlled (CNC) machines for propulsors that range in diameter up to 48-inches. Specifically, the contractor must be capable of fabricating propulsors using the inserted-blade technique where the propeller size range in diameter is up to 48-inches. Additionally, the contractor must be capable of fabricating propulsors using both the mono-block and inserted blade techniques where the range in diameter is up to 24-inches. The contractor must be capable of fabricating propulsors using a number of different materials, which include Aluminum alloy, Bronze, Nickel Aluminum Bronze (NAB), Plexiglas and other reinforced plastics. Required tolerances for propulsors are:

- Up to (±) 0.005 inches for diameter, chord-length, camber and thickness
- Up to (±) 0.005 inches for leading edge radius
- Up to (±) 6 minutes of angle for propeller pitch
- Up to (±) 3 micro-meters for surface finish (IAW ISO R484 for Class S Ship Screw Propellers)

c. The contractor shall be able to provide design, engineering support and installation in the area of model fabrication. This would include but not be limited to the design of hulls and all associated hardware, appendages, and dynamometry setup and installation. The contractor shall also have the capability to refurbish and retrofit model hulls, rings, nose sections, and all associated parts that comprise the hull, both external and internal components (e.g., dynamometers).

Task Area 14 Full-Scale Trials Testing and Flight Test Demonstrations and Development Activities

a. Develop a trials plan by determining the objective of the set of trials, determine the measurements which must be made to accomplish trial objectives, specify and fabricate the instrumentation needed to obtain the required measurements, prepare instrumentation plans and briefs, establish the support requirements for the trials, and develop the format in which data is to be recorded.

b. Plan and participate in the conduct of trials by preparing installation briefs and drawings, fabricat and install test equipment on board the vessel, acquire data during the trials, reduce and analyze test data, remove test instrumentation and restore the vessel to its pretrial condition, and prepare post-trial short reports.

c. Provide reports documenting the results of the above analyses in the format identified in the individual statements of work and within industry standard practices.

d. Development and testing of software structure-borne trials data acquisition, and the analysis of submarine and surface ship silencing and machinery mechanical health.

Task Area 15 Computer Design Generation and Evaluation of Total Ship Impact of Subsystems Related to Hydrodynamics

a. Design computer programs reflecting the impact of seakeeping on mission capability and ship size, while not degrading maneuvering or powering performance.

b. Evaluate a parametric series of hullforms analytically for both seakeeping and resistance characteristics. Evaluate the best hullforms in the series for total ship impact for a variety of missions.

c. Collect, collate and organize subsystems technical data to develop databases of technical facts and information to be used in reviewing program/project plans addressing the total ship.

d. Identify parametrically low cost of construction hulls that also offer improved hydrodynamic performance.

e. Develop algorithms to provide real-time alternative course/speed combinations subject to various ship mission objectives and subsystem operational constraints.

f. Develop algorithm programs to provide effects of ship motions on human operator performance degradation.

g. Evaluate the effect of large hydrodynamic appendages such as towed arrays and sonar domes and their associated equipment on the ship resistance, propulsion, stability, total displacement, internal volume and other ship characteristics that may be significantly affected. Provide design

support for modifying the ship design to minimize any adverse ship impact due to these hydrodynamic appendages.

h. Provide reports documenting the results of the above analyses in the format identified in the individual statements of work and within industry standard practices.